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PROJECT PLAN: TOWER AUTOMATED GROUND SURVEILLANCE SYSTEM DEVELO--ETC(U)
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(6) **PROJECT PLAN: TOWER AUTOMATED GROUND
SURVEILLANCE SYSTEM DEVELOPMENT PROGRAM,**

(14) M.E./Perie

Federal Aviation Administration
Systems Research and Development Service
Washington, D.C. 20950

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FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590**

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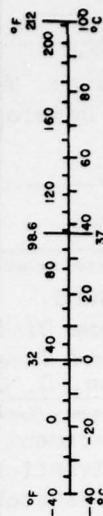
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|----------------------------|------------------------|----------------------------|---------------------|-----------------|
| LENGTH | | | | |
| in | inches | 2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| AREA | | | | |
| in ² | square inches | 6.5 | square centimeters | cm ² |
| ft ² | square feet | 0.09 | square meters | m ² |
| yd ² | square yards | 0.8 | square meters | m ² |
| mi ² | square miles | 2.6 | square kilometers | km ² |
| | acres | 0.4 | hectares | ha |
| MASS (weight) | | | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| VOLUME | | | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| ft ³ | cubic feet | 0.03 | cubic meters | m ³ |
| yd ³ | cubic yards | 0.76 | cubic meters | m ³ |
| TEMPERATURE (exact) | | | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|----------------------------|-----------------------------------|-------------------|------------------------|-----------------|
| LENGTH | | | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| km | kilometers | 1.1 | yards | yd |
| | | 0.6 | miles | mi |
| AREA | | | | |
| cm ² | square centimeters | 0.16 | square inches | in ² |
| m ² | square meters | 1.2 | square yards | yd ² |
| km ² | square kilometers | 0.4 | square miles | mi ² |
| ha | hectares (10,000 m ²) | 2.5 | acres | |
| MASS (weight) | | | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| VOLUME | | | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| m ³ | cubic meters | 35 | cubic feet | ft ³ |
| m ³ | cubic meters | 1.3 | cubic yards | yd ³ |
| TEMPERATURE (exact) | | | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



*1 in = 2.54 (exact). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10.286.

PROJECT PLAN
TOWER AUTOMATED GROUND SURVEILLANCE SYSTEM
DEVELOPMENT PROGRAM

Introduction

The Tower Automated Ground Surveillance System (TAGS) represents an important step in providing automation support for air traffic controllers in the tower cab. In recent years, many changes in ATC procedures, requirements and technology have evolved, necessitating a very careful analysis and definition of TAGS and its development program. The purpose of this project plan is, therefore, to describe the analyses and feasibility tests necessary to define the TAGS development activity.

Objective

The objective of the TAGS development program is to develop automation and surveillance aids for the Airport Surface Traffic Control (ASTC) System to increase surface traffic handling capacity, minimize delays, and provide all-weather control and guidance.

During FY-78 the objective of the TAGS activity is to perform the necessary analyses and feasibility tests to define the TAGS development program. This project plan describes the FY-78 activity. At the end of this effort, a TAGS Engineering and Development Program Plan (EDPP) will be completed.

Need

The provision of the Airport Surface Detection Equipment (ASDE-3) to major airports will satisfy many ASTC system requirements. However, studies have shown that at the largest air carrier airports, ASDE-3 satisfies only part of the system needs and significant delays will continue to occur. The "Delay Task Force Study for Chicago O'Hare International Airport" (Ref. 1) is one of the most recent and important of these studies citing the continuing ASTC problem.

The primary ASTC capacity bottleneck expected to remain after implementation of ASDE-3 is saturation of ground control during bad visibility conditions. The limiting factor in ground control capacity has been determined to be saturation of the controller's VHF communication channel. References 2, 3, and 4 discuss this problem in detail, and conclude that a major contributor to voice channel saturation is simply aircraft position reporting. TAGS,

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|-----------------------|-------------------------------------|
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| Buff Section | <input type="checkbox"/> |
| iced | <input type="checkbox"/> |
| IGN | |
| ON/AVAILABILITY CODES | |
| Dist. | AVAIL. and/or SPECIAL |
| A | - |

with a clear uncluttered presentation of each target and its identity, will eliminate the voice channel saturation problem and thus permit ground control capacity in bad visibility to equal that in good visibility. Reference 4 shows that this benefit at Chicago O'Hare alone justifies the development and implementation costs of TAGS.

Additional safety and workload benefits will accrue to TAGS. It will also become the baseline automation system to increase ASTC system capacity in the future ATC system.

TAGS History

A number of tests and analyses have been performed which have contributed to the TAGS requirements and system definition to date. They include references 2-4 discussed previously. Others are described below.

1. Operational Requirements Analyses

A number of activities have been undertaken by TSC since 1971 in an attempt to formulate operational requirements for the ASTC system. These activities included site surveys, simulations, display analyses, etc. Some of the conclusions pertinent to TAGS are listed below. A bibliography of these studies is available and will be included in the TAGS EDPP.

- 1) It is feasible to display alpha-numeric identifiers for surface targets without excessive display clutter.
- 2) Synthetic displays are preferred by controllers, but ASDE is required for backup, due to the controllers' perception of reliability of the computer-based TAGS system.
- 3) Each controller should see identity tags for only his traffic.
- 4) Small alphanumeric character sizes (1/4") are acceptable within viewing distances normal to ground controllers.
- 5) Desirability of ramp coverage, observation of non-beacon equipped vehicles, and need for aircraft extent (size and shape) information is a matter of individual airport procedures and layout and differs from airport to airport.

- 6) There is no apparent requirement for a Local Control TAGS display of ASR-type information such as distance and time to threshold of the next arrival.

2. ATCRBS Trilateration Testing

A brassboard model of the Bendix GEOSCAN system was purchased by TSC during FY-75, and was tested at NAFEC. The results showed that:

- 1) ATCRBS trilateration was indeed technically feasible;
- 2) it was very accurate - the standard deviation of error in position measurement was less than 13 feet;
- 3) it was not vulnerable to interference from other beacon interrogators.

The brassboard system is currently under test at Boston Logan. The tests are not yet complete, but preliminary results show that:

- 1) multipath has not yet been a problem - accuracy measurement errors have been less than 20 feet, one sigma;
- 2) the system has not caused interference to the ARTS in the Logan TRACON, or NAS at Boston ARTCC, even when operated at higher than normal power and PRF.

In summary, ATCRBS trilateration is an excellent surveillance system from a technical viewpoint.

3. ASDE-3

The ASDE-3 development deserves mention here. The specification has evolved over several years and is designed as a highly accurate radar system, even during periods of heavy rainfall. The radar is being built to be compatible with the later addition of a digital scan converter and/or a radar digitizer. Neither of these additions, however, is under procurement currently, although specifications are available. The digital scan converter is currently programmed as an ASDE enhancement in FY-79. The development of the ASDE digitizer depends upon its utility in the TAGS development.

Issues

The functional requirements for TAGS have thus been defined. The primary requirement is the provision of alpha-numeric target identifiers on the ground controller's display.

Certain ground rules have been adopted during the course of developing TAGS requirements. The most important is that no new avionics requirements will be levied on the user. The reason for this is the limited number of airports (4-9) at which TAGS might be implemented (Ref. 4).

Major system issues remain, however. The first is determination of the TAGS surveillance subsystem. Many alternatives exist and are described below. The second issue is display type. Two major alternatives exist: a purely synthetic display and a hybrid display, analog radar with digital symbols and alpha-numerics. Many mechanization options exist for these two display types, and they are discussed below. Also at issue (if the display type is hybrid) is the method of achieving a BRITE presentation - optical versus digital scan conversion.

APPROACH

The FY-78 TAGS program consists of a four-part effort to choose the most viable set of alternatives and to generate an EDPP which describes a well-structured, achievable and affordable TAGS development program for future years. The FY-78 efforts are shown in Figure 1 and described below.

Task 1. TAGS Alternatives Analysis

The goal of the alternatives analysis is to explore the technical feasibility, operational acceptance and costs for each alternative mechanization of TAGS. The study will organize existing data, conduct brief analyses to generate unavailable data, and will identify R&D issues to address remaining unanswered questions.

The products of the study are:

- a. A system description of each alternative mechanization including discussions of hardware, software and controller interface;
- b. A preliminary design for Chicago O'Hare International Airport (ORD) including system layout on the field and in the tower cab;

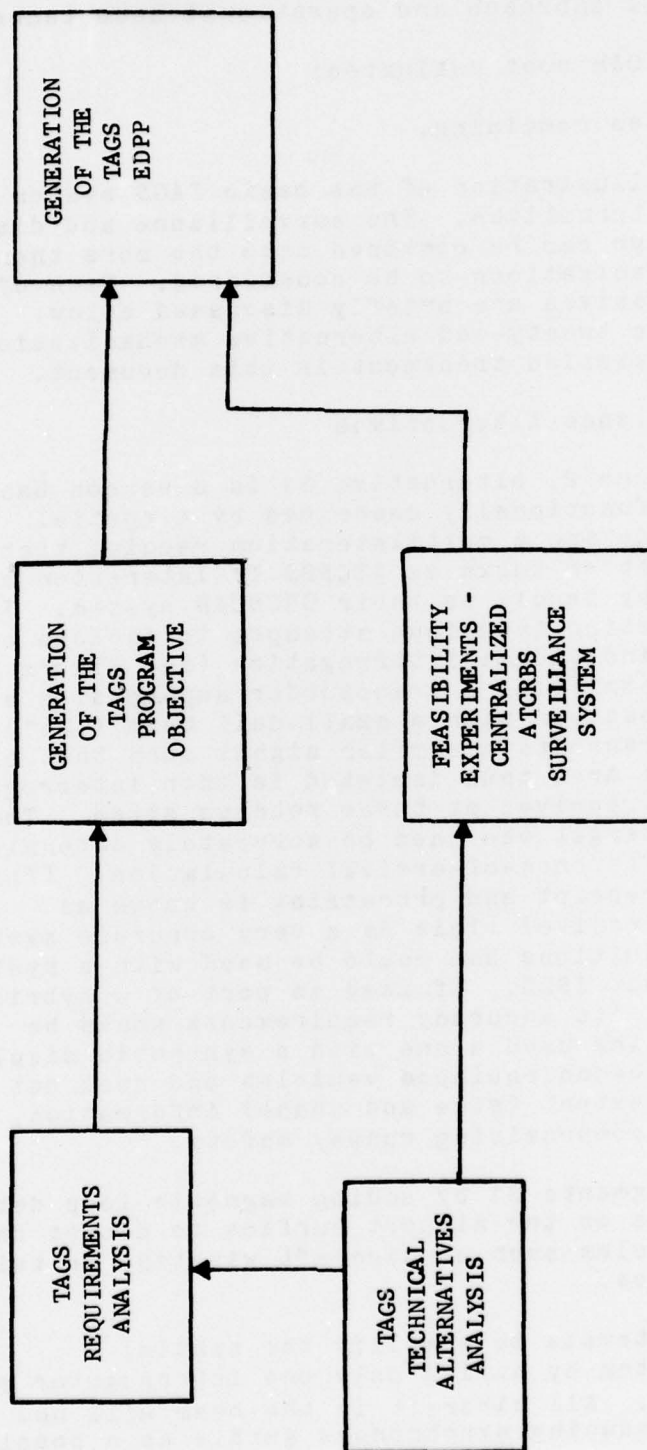


FIGURE 1 - FY-78 TAGS DEVELOPMENT PROGRAM

- c. Discussion of feasibility (risk) of both the technical approach and operational acceptance;
- d. F&E and O&M cost estimates;
- e. R&D issues remaining.

Figure 2 is an illustration of the basic TAGS system mechanization alternatives. The surveillance and display alternatives shown can be combined into the more than twenty alternative mechanizations to be considered. Each of these subsystem alternatives are briefly discussed below. The complexity of the twenty-odd alternative mechanizations precludes more detailed treatment in this document.

A. TAGS Surveillance Alternatives

Referring to Figure 2, alternative S1 is a beacon based system which is functionally described by a spatial interrogation mode and a multilateration receive technique. This system is better known as ATRBS Trilateration and has been fabricated by Bendix as their GEOSCAN system. The spatial interrogation technique attempts to isolate each transponder for individual interrogation (see Figure 3). It does this by transmitting a transponder suppression signal on a difference pattern with a small null beam (.25°). A second antenna transmits a similar signal such that the null beams cross. The area thus isolated is then interrogated, and the reply is received at three receive sites. The location of the target can then be accurately determined by a simple time-difference-of-arrival calculation. (This system of reply receipt and processing is known as multilateration receive) This is a very accurate system in all operating conditions and could be used with a synthetic display and without ASDE. If used as part of a hybrid system with ASDE, its accuracy requirements would be reduced. When being used alone with a synthetic display it is blind to non-beacon equipped vehicles and does not provide aircraft extent (size and shape) information, thereby possibly compromising runway safety.

Alternative S2 augments S1 by adding magnetic loop detectors at critical points on the airport surface to detect the presence of obstacles such as aircraft wingtips or tails and unequipped vehicles.

Alternative S3 attempts to simplify the spatial interrogation system by having only one interrogator site centrally located. All aircraft in the beam will now be interrogated introducing synchronous garble as a possible

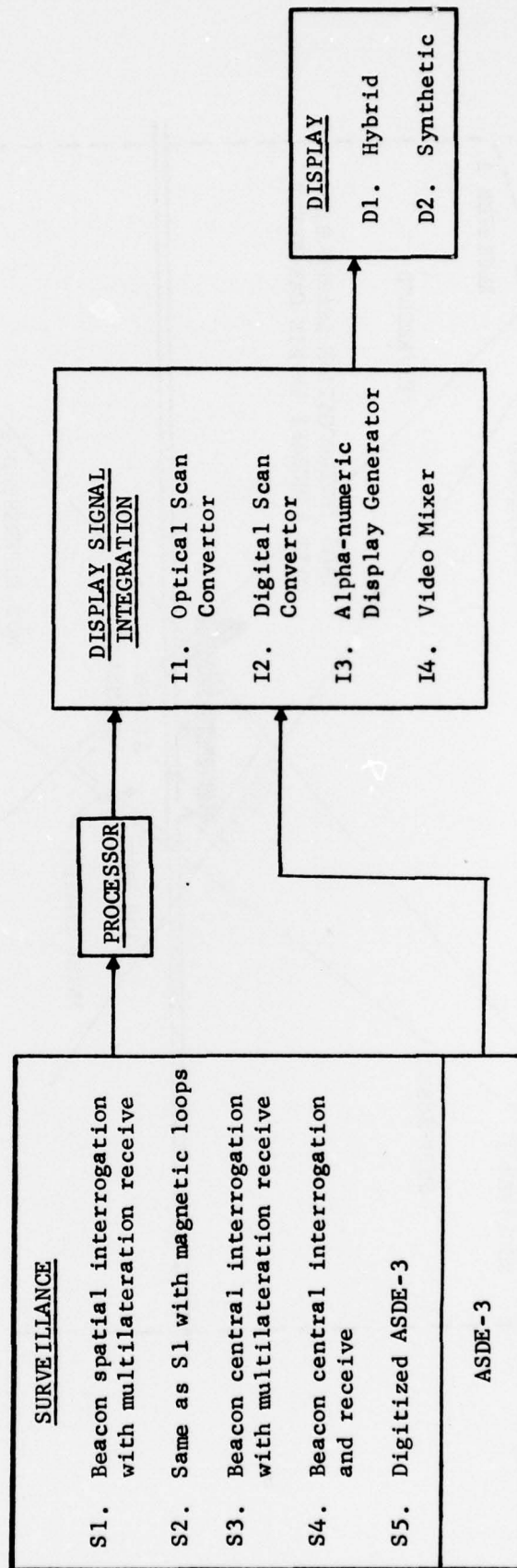


FIGURE 2 - TAGS SYSTEM ALTERNATIVES BLOCK DIAGRAM

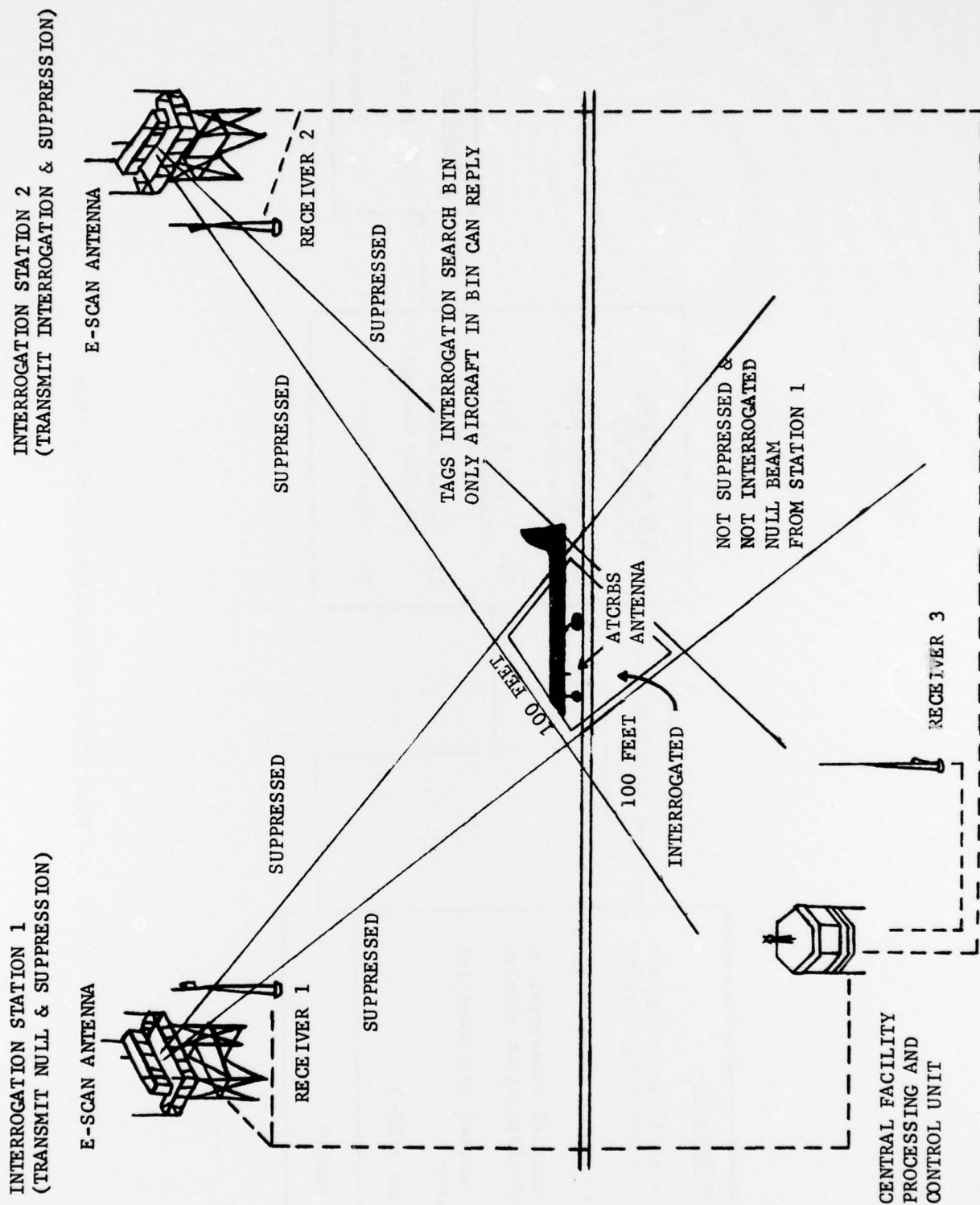


FIGURE 3 - ATCRBS TRILATERATION

problem. Also, since one site must survey the entire surface, it would have to be elevated (anywhere from 100 to 300 feet above the airport surface), and the feasibility and accuracy limitations of an elevated antenna interrogating and receiving replies from surface aircraft with belly-mounted transponder antennas is not known. The interrogator antenna could either be rotating or a system of phased arrays. It is presumed that this system, if technically viable, would be less costly than the spatial interrogation technique.

A further reduction in complexity (and cost) is attempted in alternative S4 by eliminating the multilateration receive mode. This single antenna system suffers from a significant loss of accuracy and could only be used with a hybrid display if at all.

Alternative S5 eliminates the beacon system altogether and relies on tracking of digitized ASDE-3 data to determine identity. This would require an ARTS-III interface and manual input to correlate aircraft identification and target returns. Major technical feasibility questions and increased controller workload are the major drawbacks to this alternative.

B. TAGS Processor

The processor requirements vary with both the surveillance and display alternatives used. Very sophisticated processing is required for surveillance alternative S1, whereas S4 requirements are relatively simple. The demands for display output formatting and timing vary greatly also.

C. TAGS Display Signal Integration

Display signal integration is necessary only for the Hybrid display option. The synthetic display could be driven directly from the TAGS processor. The alternatives (I1 through I4) shown in Figure 2 are not separable alternatives, but rather are devices used in various combinations to produce output for the hybrid display. Four possible alternative combinations are shown in Figure 4.

An optical scan converter (I1) is an analog device consisting basically of a TV camera and associated electronics. The radar PPI display is used as input. It is "photographed" by the TV camera and the high update rate from the TV system can be used to generate the BRITE tower display. This is the system used in the field today for all tower BRITEs. Optical scan converters are difficult to build in production, repeatability of performance is more an

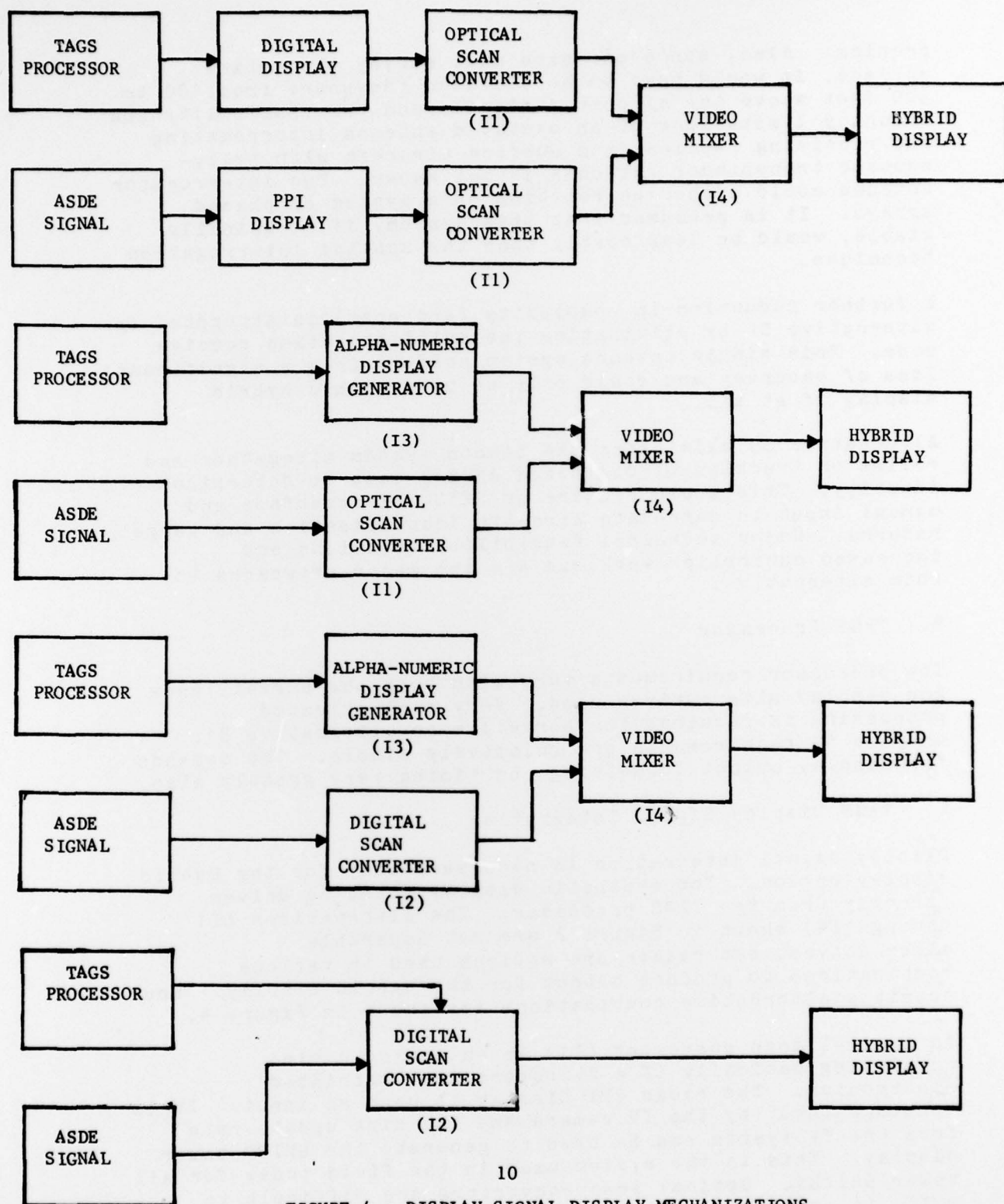


FIGURE 4 - DISPLAY SIGNAL DISPLAY MECHANIZATIONS

art than a science, and the device is therefore difficult to set up and maintain in the field.

The digital scan converter (I2) is a device designed to eliminate the shortcomings of optical scan conversion. The analog radar video is converted to digital, stored in memory, and read out and converted back to analog in a synchronous manner to generate a TV signal. Note that the final mechanization shown in Figure 4 requires a more sophisticated design than the mechanization immediately preceding it. This is a development item and has potential in O&M cost reduction for both ASTC and ASR BRITE displays in the tower cab.

The alpha-numeric display generator (I3) is a device which generates alpha-numeric characters and symbols in a TV format. A video mixer (I4) simply superimposes two TV inputs into one TV output signal.

D. TAGS DISPLAY

The hybrid display (D1) is a BRITE TV display. It shows the ASDE video and would superimpose target identifiers correlated with the target position. Note that this correlation is relative, based on the absolute target location as determined by two independent (ASDE and TAGS) sensor systems.

The synthetic display would be an all-digital, stroke-written, BRITE display similar to the MAGNAVOX Tower Cab Digital Display being used in the ARTS III Tampa-Sarasota project. This display has the advantage of a crisp, clean, uncluttered presentation.

TASK 2 - TAGS Requirements Analysis

As can be seen from the discussion of Task 1, the TAGS alternatives are many and complex. The analysis of these alternatives is, however, a necessity not only to simplify the TAGS development program, but also because it will become an integral part of the requirements analysis.

The purpose of the requirements analysis is to provide a vehicle for agency approval of the TAGS program. The product of the requirements analysis will be a TAGS requirements statement. The analysis and resulting requirements statement will be in accordance with FAA Order 1810.1 "System Acquisition Management."

This task is being carried out as a joint effort with OSEM (AEM-100).

TASK 3 - Feasibility Experiment: Beacon Centralized Interrogation

As discussed under Task 1, the technical feasibility of the Beacon Centralized Interrogation technique (surveillance alternatives, S3 and S4, Figure 2) has not been proven. The ATCRBS Trilateration system tests being conducted at Boston Logan International Airport can conveniently be extended to perform the required feasibility experiments. The approach would be to move one of the electronically scanned antennas from its present location to the roof of the old tower building. Only a portion of the Logan surface could be surveyed, but coverage would be sufficient for the feasibility experiment. The present availability of resources, both manpower and equipment, plus the potential for cost savings, makes the feasibility investigation of centralized beacon interrogation a logical portion of the FY-78 TAGS program.

TASK 4 - Generation of the TAGS EDPP

This final task of the FY-78 TAGS program is the generation of an Engineering and Development Program Plan for TAGS in accordance with SRDS Order RD 9500.6. The plan will document the TAGS program objective and define a comprehensive effort to achieve that objective. The EDPP is the final product of the FY-78 TAGS program.

RESOURCES/SCHEDULES

The TAGS subprogram (143-103) is a part of the Airport Surface Traffic Control program element (143). M. Perie, ARD-102, is the ASTC program manager.

Portions of tasks 1, 2, 3 and 4 will be accomplished by TSC. Sufficient in-house resources have been allocated by TSC to support these tasks and to complete ATCRBS Trilateration tests.

The remainder of tasks 1 and 2 is to be accomplished through OSEM by TSC and MITRE analysts. These resources have been secured by AEM-100.

The TAGS EDPP will be written by the ASTC program manager.

The only contractual resource required is \$50,000 to accomplish the beacon centralized interrogation feasibility experiment. This was not in the FY-78 R&D program, but has been covered by reallocation within ARD-100 resources.

The schedule for the FY-78 TAGS development is shown in Figure 5.

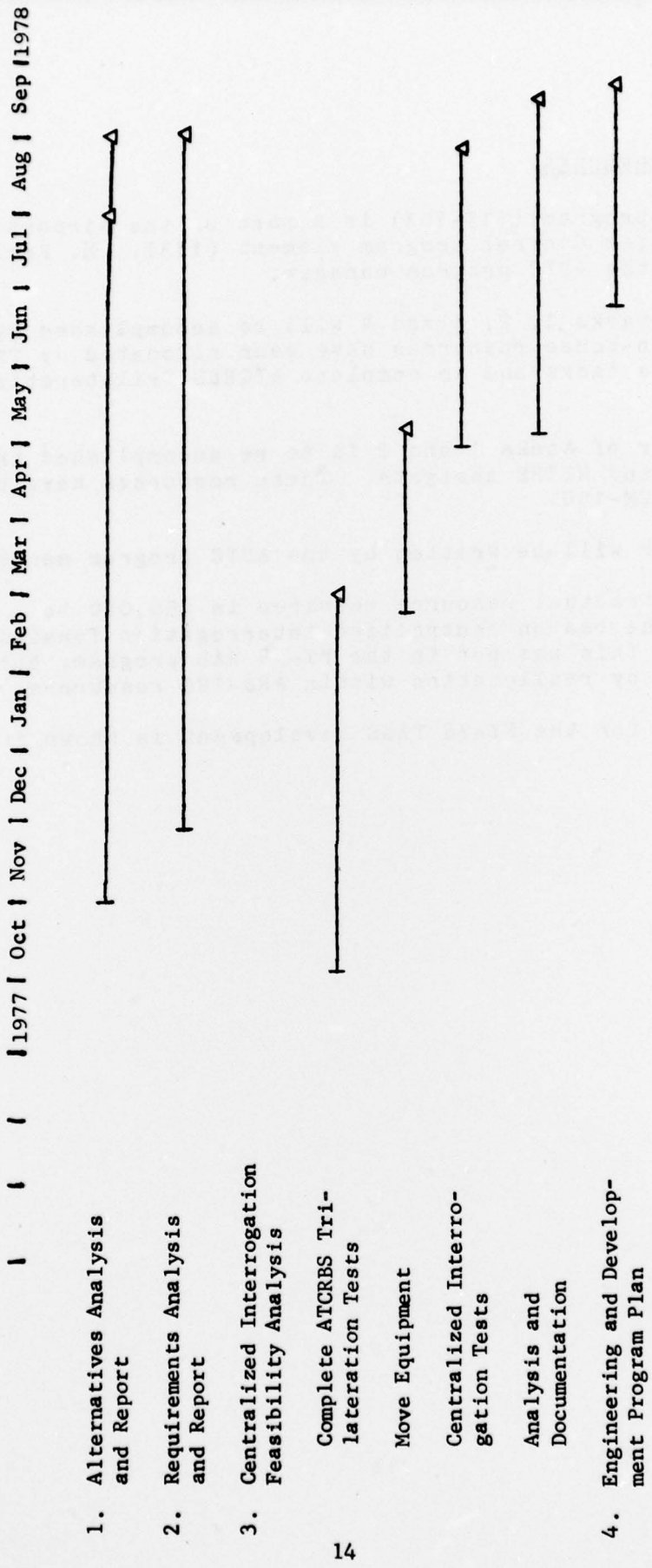


FIGURE 5: FY-78 TAGS DEVELOPMENT PROGRAM SCHEDULE

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